

THE NNPDF2.1 PARTON SET

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We discuss the main features of the recent NNPDF2.1 NLO set, a determination of parton distributions from a global set of hard scattering data using the NNPDF methodology including heavy quark mass effects. We present the implications for LHC observables of this new PDF set. Then we briefly review recent NNPDF progress towards NNLO sets, and in particular the impact of the treatment of fixed target NMC data on NNLO Higgs cross sections.

The NNPDF2.1 parton set The NNPDF2.1 set¹ is a NLO determination of parton distributions from a global set of hard scattering data using the NNPDF methodology including heavy quark mass effects. In comparison to the previous parton fit, NNPDF2.0², mass effects have been included using the FONLL-A General-Mass VFN scheme³ and the dataset enlarged with the ZEUS and H1 charm structure function F_2^c data. The kinematical coverage of the datasets included in the NNPDF2.1 analysis is summarized in Fig. 1. As in NNPDF2.0, we use the FastKernel framework for fast computation of Drell-Yan observables to include these data exactly at NLO accuracy in all stages of the PDF determination, without the need to resort to any K-factor approximation.

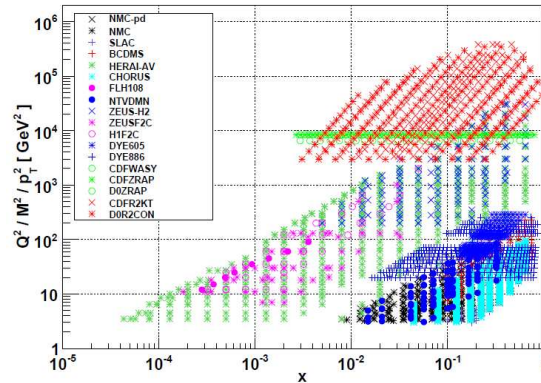


Figure 1: Experimental data sets which enter the NNPDF2.1 analysis.

The NNPDF2.1 PDFs are compared to the other two NLO global PDF sets CT10⁴ and MSTW08⁵ in Fig. 2. One finds generally good agreement of the three gluon distributions, except in the region $x \lesssim 0.1$ where the agreement is marginal, with implications for important processes like Higgs production. There are also differences from the singlet PDF, part of which

can be traced back to the different treatment of strangeness in each set.

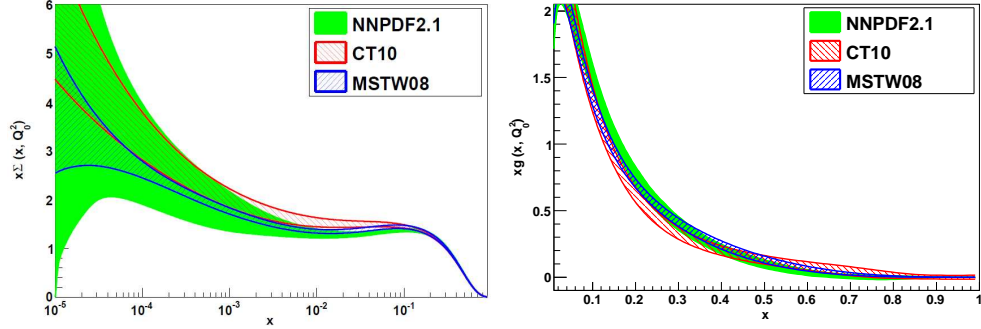


Figure 2: The singlet and gluon NNPDF2.1 PDFs, compared with the CT10 and MSTW08 PDFs. The results for NNPDF2.1 have been obtained with $N_{\text{rep}} = 1000$ replicas. All PDF errors are given as one- σ uncertainties.

LHC phenomenology The assessment of the theoretical uncertainties on LHC standard candles is especially important now that the first 7 TeV LHC results on inclusive cross-sections are appearing. In Ref. ¹ we presented results at $\sqrt{s} = 7$ TeV and $\sqrt{s} = 14$ TeV for W^\pm , Z_0 , $t\bar{t}$ and Higgs production in gluon fusion. All observables were computed at NLO QCD using MCFM. We compared the predictions for these cross-sections obtained using the NNPDF2.1, NNPDF2.0, CT10 and MSTW08 sets. In the case of the last two sets, results were computed both using the respective default value of $\alpha_s(M_Z)$ and at the common value of $\alpha_s(M_Z) = 0.119$. A subset of these results, the NLO cross sections for W^+ and $t\bar{t}$ production at LHC 7 TeV, is shown in Fig. 3.

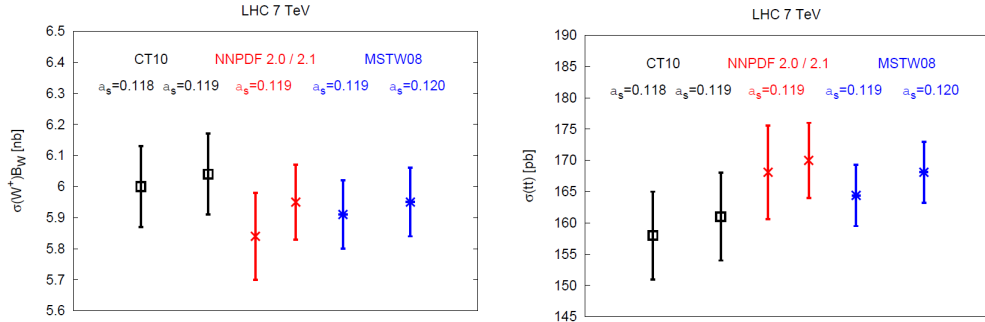


Figure 3: LHC standard candles: W^+ and $t\bar{t}$ production.

The differences between NNPDF2.0 and NNPDF2.1 are at most at the one- σ level for W and Z production, while predictions for the $t\bar{t}$ and Higgs are essentially unchanged: these observables are only minimally affected by the heavy quark treatment. NNPDF2.1 predictions are in rather good agreement with MSTW08 for all observables, though differences with CT10 are somewhat larger, especially for observables which are most sensitive to the gluon distribution, like Higgs and $t\bar{t}$ production. The use of a common value for the strong coupling α_s leads to better agreement between predictions, especially for processes which depend on α_s already at leading order such as Higgs production in gluon fusion.

Dependence on heavy quark masses The dependence of PDFs on the heavy quark masses has been studied by repeating the NNPDF2.1 fit with different mass values. In particular, we have repeated the reference fit for charm quark masses m_c of 1.5, 1.6 and 1.7 GeV as well as for

bottom masses m_b of 4.25, 4.5, 5.0 and 5.25 GeV. It is important to observe that at the order at which we are working, the perturbative definition of the heavy quark mass is immaterial: indeed different definitions (such as, for example, the pole and $\overline{\text{MS}}$ mass definitions) differ by terms of $\mathcal{O}(\alpha_s^2)$ only.

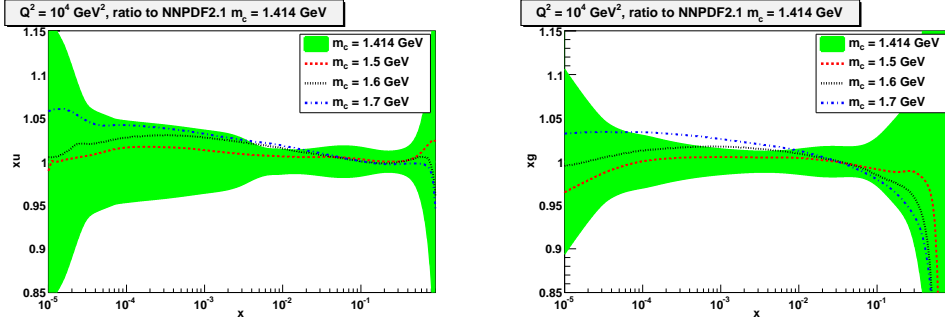


Figure 4: Ratio of NNPDF2.1 PDFs obtained for different values of the charm quark mass to the reference NNPDF2.1 set at $Q^2 = 10^4 \text{ GeV}^2$. Left: up PDF ratio; right: gluon PDF ratio.

Selected results are shown in Fig. 4 where the ratio of PDFs for different values of m_c to the reference NNPDF2.1 fit are plotted as a function of x for $Q^2 = 10^4 \text{ GeV}^2$. The dependence of the heavy quark PDFs on the value of the mass can be understood: heavy quark PDFs are generated radiatively, and assumed to vanish at a scale equal to their mass. Therefore, a lower mass value corresponds to a longer evolution length and thus to a larger heavy quark PDF, and conversely. Because of the momentum sum rule, if the charm PDF becomes larger, other PDFs are accordingly smaller (and conversely).

The variation of the W and Z cross section is at the percent level for charm mass variations of order of 10%, as can be seen in Fig. 5. It is also interesting to observe that the variations seen when modifying sub-leading charm mass terms is of the same order of magnitude and in fact somewhat larger. This suggests that even though PDF uncertainties on standard candles are still dominant at present, theoretical uncertainties related to the treatment of charm will become relevant and possibly dominant as soon as PDF uncertainties are reduced by a factor of two or three.

NMC data and NNLO Higgs production at colliders Recently, there have been claims⁶ that differences in the treatment of fixed-target NMC data in global PDF analysis has a large impact for predictions of Higgs production at hadron colliders. More precisely, Ref. ⁶ claims that replacing NMC structure functions (as used by CT, MSTW and NNPDF) with reduced cross sections lowers by a sizable amount the predictions for Higgs cross section in gluon fusion at the Tevatron and the LHC, with important implications for the definition of exclusion limits in Higgs searches.

In Ref. ⁷ we addressed this issue using the NNPDF2.1 NLO set and found that nor using cross-section data instead of structure functions for NMC neither removing NMC altogether from the global fit leads to any appreciable modification of the NLO predictions for Higgs production at the Tevatron and the LHC. However, Ref. ⁶ finds that this effect is much more important at NNLO than at NLO. Using the preliminary NNPDF2.1 NNLO set, we have performed a similar analysis than the one performed at NLO. Although a more detailed description of the result will be presented elsewhere, here we present the main conclusions of this new study.

We have produced a NNPDF2.1 NNLO set based on structure functions for NMC proton data instead of the default choice of reduced cross sections. In Fig. 6 we compare the NNLO gluon for the two fits: it is clear that they are statistically equivalent. We have also computed the NNLO Higgs production in gluon fusion cross section in the two cases. Again from Fig. 6

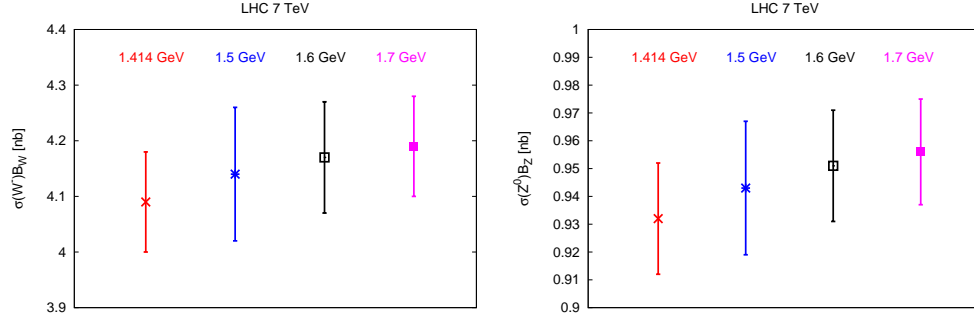


Figure 5: The total NLO W^- and Z^0 cross sections computed with the NNPDF2.1 set with varying charm quark mass m_c .

it is clear that also at NNLO the details of the treatment of NMC data are irrelevant for the predictions of Higgs production cross sections at hadron colliders.

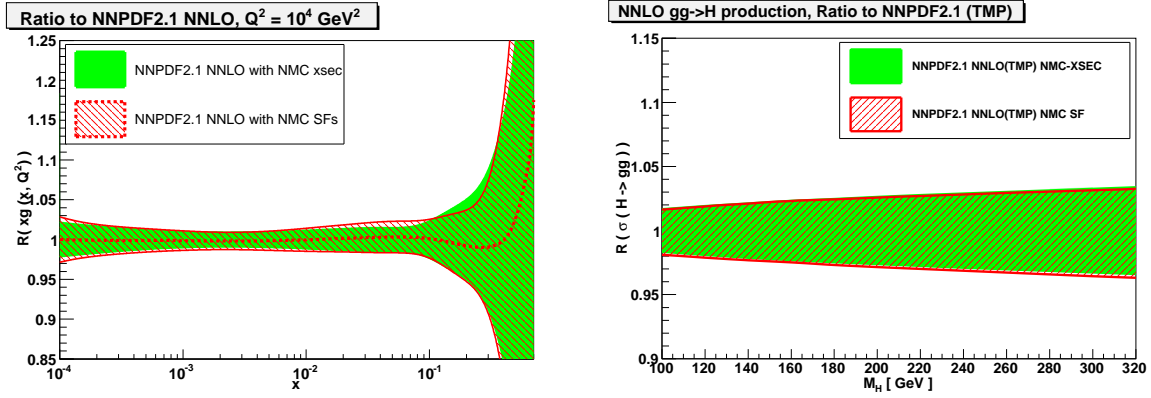


Figure 6: Left plot: Comparison of the ratio of the NNPDF2.1 NNLO gluon for the fits with the different treatment of NMC data. Right plot: The total NNLO Higgs cross section in gluon fusion from the preliminary NNLO NNPDF2.1 sets, comparing the fits in which NMC data is treated at the level of structure functions and at the level of reduced cross sections.

Therefore we have shown that the treatment of NMC data does not induce appreciable modifications for Higgs production at hadron colliders. Note however that in Ref.⁶ the strong coupling was also fitted, and its best fit value was found to strongly depend on the treatment of NMC data. Our results show that if α_s is kept fixed, the impact of the treatment of NMC data is negligible.

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